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EVALUATION OF AN UNDERGROUND COAL MINE MONITORING SYSTEM

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by

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ABSTRACT

As a result of a contract initiated by CANMET with Conspec control Ltd. of Toronto, a prototype for a new generation of intrinsically safe mine monitoring systems has been developed. The prototype system was installed in the hydraulic mine operated my Westar Mining Ltd. at Sparwood, B.C. in early 1984 to evaluate its performance. The monitoring system was operated jointly by CANMET and Westar Mining Ltd., and its evaluation continued till January 1985 when the mine had to be sealed off unexpectedly because of an underground fire.

This R & D work provided valuable experience to the manufacturer, Westar mine and to CANMET personnel and helped in resolving a number of operating problems common with most new prototype systems.

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ÉVALUATION DU CIRCUIT DE CONTRÔLE D'UNE MINE DE CHARBON SOUTERRAINE

par

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RÉSUMÉ

En vertu d'un contrat octroyé par le CANMET à la Conspec Control Ltd. de Toronto, le prototype de nouveaux circuits de contrôle essentiellement sécures a été mis au point et installé dans la mine hydraulique exploitée par la Westar Mining Ltd. à Sparwood (B.C.) au début de l'année 1984 afin que l'on puisse en évaluer la performance. Le circuit de contrôle a été exploité conjointement par le CANMET et la Westar Mining Ltd. L'évaluation de la performance du circuit s'est poursuivie jusqu'en janvier 1985 quand la mine a dû être fermée inopinément en raison d'un incendie souterrain.

Les travaux R-D ont permis au fabricant, à la Westar et au personnel du CANMET d'obtenir une expérience précieuse et ont facilité la solution d'un grand nombre de problèmes de fonctionnement, communs à la majorité des circuits de contrôle.

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INTRODUCTION

The coal mine environmental research group at the CANMET Calgary Coal Research Laboratory had, in the early 1980's, formed the opinion that an automatic computer controlled coal mine environmental monitoring system should be installed in western Canada to demonstrate to mine operators the potential benefits that such a system could provide, in particular:

a) Increased control over the dispersion and dilution of hazardous gas emissions and hence increase the safety of mine personnel.

b) Improved ventilation planning due to more detailed information on ventilation anomalies.

c) Early warning and location of spontaneous combustion outbreaks, disruptions to ventilation and abnormal emissions of hazardous gases.

A "Conspec Senturion 200" system which is manufactured by a Canadian company was chosen in compliance with the government policy of promoting indigenous Canadian industries. Further, USBM mining research centre has been evaluating a similar system developed by Conspec control; the results appeared to be encouraging and it was considered that maintenance and support services would be better with a system developed in Canada. Although a similar type of system made by the same company had been successfully used in hard rock mines in non-hazardous environments, extensive modifications were required to make it intrinsically safe for use in underground coal mines. Such modifications essentially placed the system into a prototype category and therefore considerable testing was essential before it could be demonstrated to the mining industry. This was necessary in order to rectify the faults and weaknesses that are usually discovered in the testing of complex prototype systems.

The testing of the Conspec system in an underground coal mine environment provided a substantial amount of information on the areas that required modifications to improve reliability. In addition, it also provided useful insights on what should be included in the initial contract agreement between the supplier and the purchaser relating to the training of operators and the rectification of system malfunctions.

SYSTEM DESCRIPTION

The Senturion 200 is a microcomputer based real-time data acquisition monitoring and control system. Its basic hardware consists of a central processor, "data" and "event" printers, communication cables and single point transmitter/receivers. A choice of two types of modems are also available which effectively increases the distance over which communications between sensor and processor can be made. This is achieved by using a telephone cable with modems at either end, one of which is connected to the communications cable and the other to the processor.

The single point transmitter/receivers transfer data from a sensor to the central processor when requested by the central processor to do so. Due to the ability of this device to recognize when it is being addressed by the processor, many sensor groups can be connected to a single communication cable. The communication cable consists of only four wires. Two of the wires are used to supply power to the transmitter/receivers and the sensors. The other two are used to transmit and receive digital signals.

Three sets of sensors were installed in the mine, one set being positioned in the main intake airway and the other two being placed in return airways. One I.S. power supply unit was used for intake sensors and the second I.S. power supply unit was used for two sets of sensors placed in the return. Each set contained sensors capable of measuring carbon monoxide, methane and airflow. Fig. 1 shows the Conspec system being tested in the Calgary laboratory.

The software provides the system with the ability to perform a number of functions. Preset alarm limits may be set for an individual, or for groups of sensors and when these alarm levels are exceeded, immediate visual and audible warning is given. If required the system can monitor trends and give a warning when a limit is about to be exceeded. Record keeping is automatic for all changes of state or alarm occurrences. Shift report printouts are used to calculate the average levels in the monitoring areas and these may be printed out at any desired frequency.

Analyzing hardware faults can be aided by using the systems self monitoring capabilities. Certain types of alarms may be used to diagnose both the type of hardware problem and the location of the fault. Basic

Fig. 1 - Conspec monitoring system being evaluated at the Calgary Laboratory

hardware problems that can be detected by the computer include the detection of breaks in the signal and power lines and electronic malfunctions in the transmitter/receivers.

INSTALLATION AND COMMISSIONING

The Conspec system was purchased in November 1982 after it had been modified and later certified by Energy, Mines and Resources in Ottawa to be intrinsically safe for use in underground coal mines. After CANMET personnel had familiarized themselves with the system at the laboratory it was transferred to the Westar underground hydraulic coal mine located in Sparwood, B.C. There was some delay in laying the communications cables because of operational problems at the mine but the system was eventually commissioned by a Conspec representative in January 1984.

OPERATIONAL EXPERIENCE

Within weeks of commissioning the system failures occurred although the system still functioned at a reduced capability. Between January and July numerous phone calls were made between CANMET in Calgary, the mine operators in Sparwood and Conspec in Toronto in an attempt to rectify these faults. Eventually a representative from Conspec was sent to assess the situation. A few days after this visit the system failed completely and unauthorized tampering by a mine employee was the suspected cause. This coincided with the annual mine holiday and so no immediate remedial action was taken.

After the holiday a reshuffle in the mine personnel operating the system occurred and attempts were made to re-commission the system without success. At this point CANMET decided to award a contract to the manufacturer, Conspec Control Ltd. to investigate the problems associated with the installation and operation of the system and to make recommendations so as to assure uninterrupted operation. The investigation was successfully completed in November 1984 and further testing of the system proceeded until a mine fire terminated the project prematurely and forcing the mine to shut down. A part of the system inside the mine could not be recovered because of the necessity to seal off all of the entries to the surface to prevent spread of fire.

SYSTEM FAILURES AND PROBLEMS

OPERATOR'S MANUALS

Some difficulty was experienced by the mine operators and by CANMET personnel in understanding the operator's manuals. This was possibly due to authors of the manual assuming that their readers would have more knowledge and experience than they actually possessed. In some instances the manuals required correction. To avoid these problems the manuals should be more exhaustive and include the fundamental principals of the system. In addition more training for the system operators should be provided.

Most of the problems and failures of the system described below are summarized from the CANMET contracted report prepared by Conspec in collaboration with the CANMET scientific authority (1).

ELECTRICAL SUPPLY

A number of system crashes were found to be caused by fluctations in the voltage level of the mine site power supply. This was rectified by the installation of a constant voltage transformer/isolator.

The uninterruptable power supply (UPS) failed which also caused the system to crash frequently. This was detected by the Conspec representative during the site visit which was subsequnetly repaired. The cause for this defect was investigated and appeared to be a manufacturing defect resulting in loose contacts.

OPERATOR'S VIDEO TERMINAL

A gradual deterioration in the video picture occurred since installation, and the picture eventually disappeared in October 1984. This was found to be due to a failure in the unit power supply which may have resulted from manufacturing defects.

COMMUNICATIONS

The problems that occurred with ensuring a reliable communication link between the host computer and the sensors proved to be one of the major headaches. In the opinion of Conspec the primary cause of such failures was due to incorrect adjustment of the communication modems. Other problems included the following.

Due to voltage drop along the communications cable only a limited length of the cable can be used. The operations manual of the system specifies a maximum of five and a half miles. The length of communication cable for one unit was over five miles and thereby operating close to this limit. This may have reduced the integrity of the data received. The length of this cable was later reduced to about four miles.

At one stage the modem and other hardware used to relay data onto the communications cable was placed inside a power substation underground. The electrical interference from such a source is evidently to be avoided and may well have caused some of the problems observed during operation of the system. This was subsequently corrected during the mine site visit by the Conspec representative.

The initial design of the system was such that if the electrical supply to a sensor was not cut off before removal of the sensor then a protective fuse would be blown. This problem was solved by installing isolation switches.

A defective modem interface card was also identified during inspection by the Conspec representative and was replaced accordingly.

SENSORS

Methanometers and air velocity sensors were found to produce faulty or erratic readings during the earlier months of the installation. These faults seemed to be due to a reduction in the instruments electronic capacitance. Both methanometers and air velocity sensors were later modified by Conspec and appeared to function correctly. Also two of the three methanometers were found to have developed problems resulting in erratic results. Conspec attributed this to unsafe handling or inadvertant cell poisoning.

SYSTEM SOFTWARE

Misunderstanding was found to occur with some of the mine operators regarding the correct interpretation of the system generated shift reports. The Conspec report referred earlier (1), dealt with this phenomenon in detail. Further training of mine operators was considered necessary for better understanding. Attempts were also made to modify the software to

filter out spurious readings but this was abandoned as some of the actual high methane concentration readings can be missed using such modification. Graphical representation of the results using a colorgraphic attachment will prove useful in dealing with the high readings caused by electronic problems.

FUTURE DEVELOPMENT OF THE CONSPEC SYSTEM

The report produced by Conspec regarding their investigation into the problems afflicting the system included a section on their intentions to improve the system and reduce the number of malfunctions. These recommendations are summarized below.

MODEMS

As a result of the problems associated with adjusting modems to provide accurate data communication between the host computer and the sensors, Conspec is now introducing "remote trunk extender stations" rather than "remote modem trunk driver stations" in their systems presently marketted. This will eliminate the modem but will require an additional power supply and trunk driver at the central processor location and also an additional pair of twisted wires for communications. However this will provide the major advantage that absolutely no adjustments will be required at underground sensor locations.

SENSORS

A number of problems were experienced with the methane and airflow sensors. Conspec has now made plans to purchase the sensor elements from the instrument suppliers and to refine their design and to simplify the calibration procedure. This will also allow Conspec to gain a better degree of control over the quality and reliability of the instruments. The two type of carbon monoxide sensors used, which were manufactured by Ecolyser and M.S.A. were found to be reliable and free from any major problems. Both of these types of sensors used electro-chemical sensing heads and performed satisfactorily and over an extended period. Like any other electrochemical cells yearly replacement is necessary for accuracy.

TRAINING

In the opinion of Conspec the single most important requirement for successful and trouble free operation of the system is adequate training of the operators. Hence they recommend a longer training period than was provided to the Westar mine personnel.

It is worth stressing the necessity for adequately trained operators since frequent calibrations and adjustments were made by Westar that in the opinion of Conspec, unnecessary or incorrect resulting in considerable lost operational time.

RECOMMENDATIONS RESULTING FROM THE TESTING OF THE CONSPEC SYSTEM

The experience gained from testing the performance of a prototype, automatic mine monitoring system in an underground coal mine has provided the manufacturer with information on the parts of the system requiring adjustment or replacement in order to improve the reliability of the system. This also provided a number of lessons that may be beneficially applied by supplier or purchaser to any future installations of mine monitoring sytems.

a) The provision of a comprehensive training program for system operators is of paramount importance for the successful performance of the system. This can be facilitated by contracting the system suppliers to provide suitable training and to ensure that all documentation and operating manuals are sufficiently detailed and readable, so that operators will have little difficulty in comprehending them.

b) If a system malfunction occurs which cannot be quickly rectified by the operators then considerable delays in recommissioning the system can result if a contract has to be negotiated with the suppliers to send a representative to correct the fault. Such lengthy delays can instill the attitude in both operators and management that the system cannot be relied upon. To prevent this problem it would seem advisable to ensure that in the original purchase contract provision is made to guarantee a rapid response by the supplier to repair any faults. This is especially important during the first year where a higher than average rate of components fail ("burn in" period).

c) The testing of any complex prototype system usually reveals its weaknesses, which can then be rectified and so improve the future reliability of the system. This has been true of the Conspec system and has led to the manufacturer identifying problems with sensors, modems and calibration modules and to future R & D work to improve reliability in these areas.

COMPARISON OF EXPERIENCE WITH THE NATIONAL COAL BOARD, UNITED KINGDOM

During the initial trials of environmental monitoring systems into the U.K. Mining industry the N.C.B. were very dependent on the supplier to install and maintain their systems. The supplier failed to do this to the satisfaction of the N.C.B. and as a result a decision was taken to reduce "supplier dependency" by adopting the following policy:

a) Obtain the services of more than one supplier and require that the hardware and software will conform to a single standard and are provided with detailed documentation. Agreements exist with suppliers that they provide a prompt repair service (usually within 24 hours).

b) Develop "in-house" system expertise and educational service for the system operators. The N.C.B. have found that it takes at least two to three weeks of full time training to achieve the necessary standard of competence.

c) All types of computer systems installed at a mine should eventually be integrated by ensuring that they are compatible with a single communication standard.

CONCLUSIONS

The testing of the Conspec system provided valuable experience to the manufacturer, the Westar mine and to CANMET personnel. This experience has similarities to that of the N.C.B. in that training of operators and ensuring a prompt repair service are of paramount importance.

In western Canada there are now very few operational underground coal mines. Therefore the demand for the type of environmental monitoring system as described in this report is correspondingly diminished. Hence, no further testing of this type of systems is envisaged in the near future for underground coal mines in western Canada. However the underground tarsands project near Fort McMurray may provide some opportunity for additional work.

Should CANMET continue to purchase and test systems similar to that produced by Conspec, some consideration may be given to the advantages of obtaining the patent rights to the details of construction and software.

Conspec construct their systems from components such as microprocessors, modems, sensors and interfaces that are manufactured by other companies. Consequently in building such systems they select the components so that they will function to a specific communication standard and then write the software which conforms to this standard to automatically operate the system. Consequently, if funds are provided to a company to develop these types of systems, the real value of such work is not only the finished product which consists of pre-manufactured components, but the time and resources spent in the designing of the hardware and in developing the operating software. If these rights were secured any other manufacturer chosen by CANMET could build and develop the system further. This would ensure that:

a) system development and marketting is not tied to a single source of supply,

b) repairs to the system could be contracted out to instrumentation specialist closer to the test site.

Until this point this paper has only discussed a specific type of automatic computer controlled data acquisition system, namely an intrinsically safe mine atmosphere system. There are however many types of systems including systems developed by Conspec which can monitor different conditions such as whether a machine is on or off, electrical power consumption, composition and flow rates of gases fluids and solids, condition of bearings, temperature and pressure, etc. These systems can also control as well as monitor and can perform operations such as switching machines on and off and opening and closing valves. These systems find important applications in the mining industry such as control of processing plants, conveyor belts,

supplies, maintenance and truck dispatching. In addition to being able to perform the above functions they can also act as a mine management systems and indeed the Conspec system acts in this role by providing shift reports and presenting historical data base to aid planning.

Since mine operators are continually searching for ways of improving efficiency of their operations the use of such systems is very likely to increase.

Although some Canadian mining companies may be sufficiently large with a computing department capable of developing automatic computer data acquisition systems, there are many companies which lack adequate computer facilities. It would be a valuable asset to these companies if an organization, such as CANMET, could research and develop computer controlled data acquisition systems and provide the results of such work at a price comensurate with cost recovery.

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